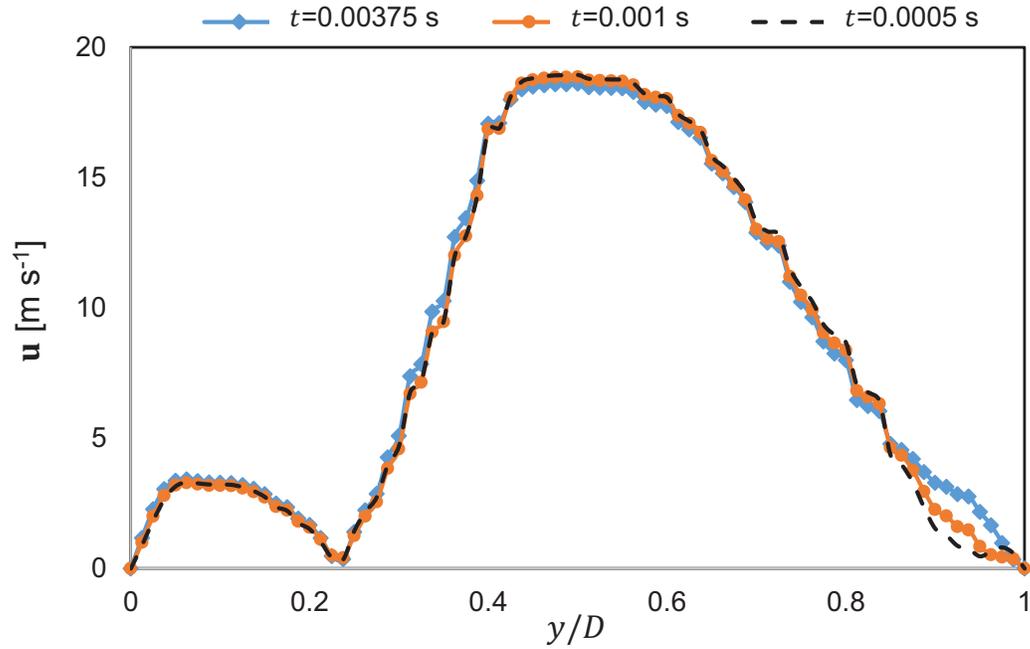


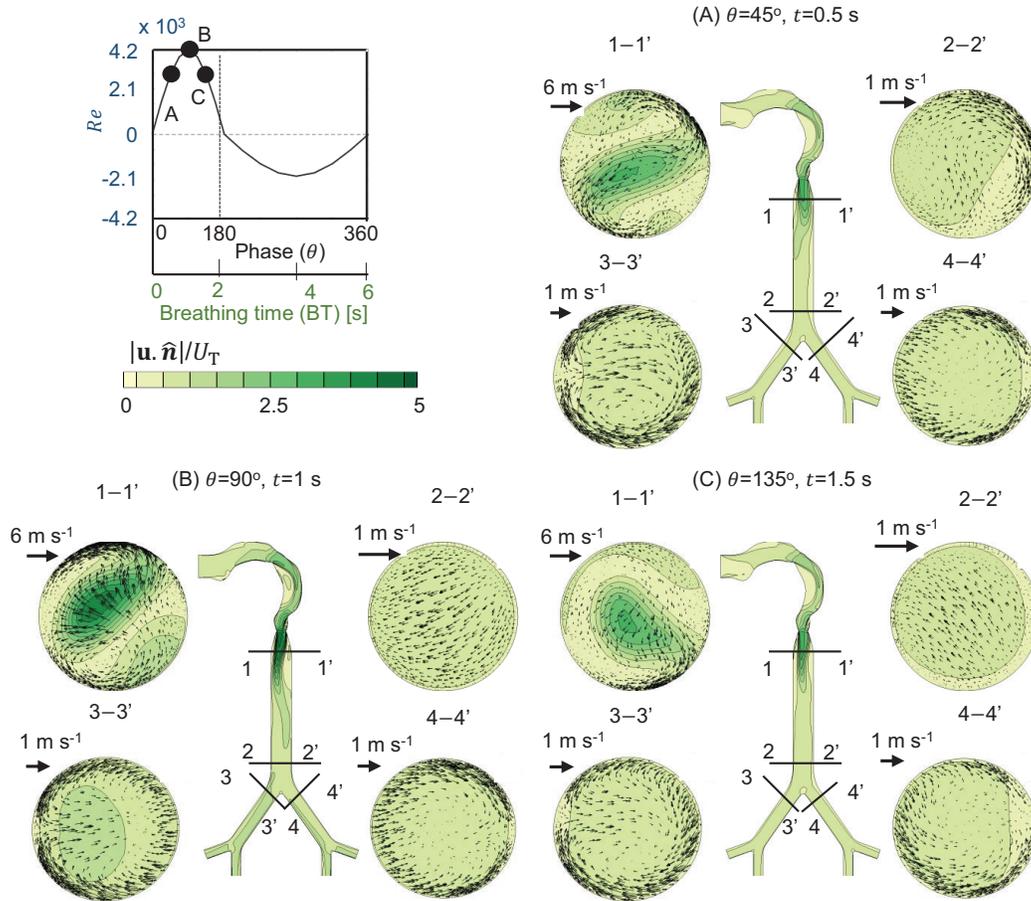
# SUPPLEMENTARY MATERIAL

*Effects of varying inhalation duration and respiratory rate on human airway flow*

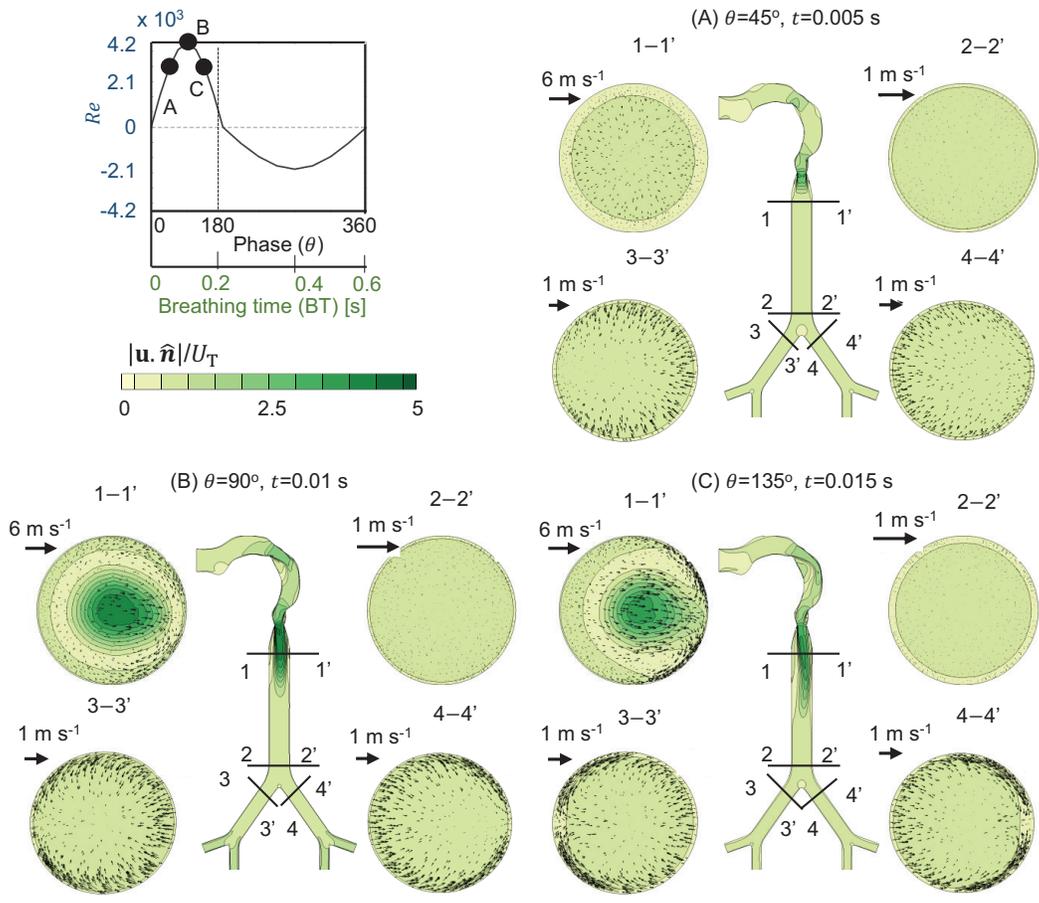
Manikantam G. Gaddam and Arvind Santhanakrishnan



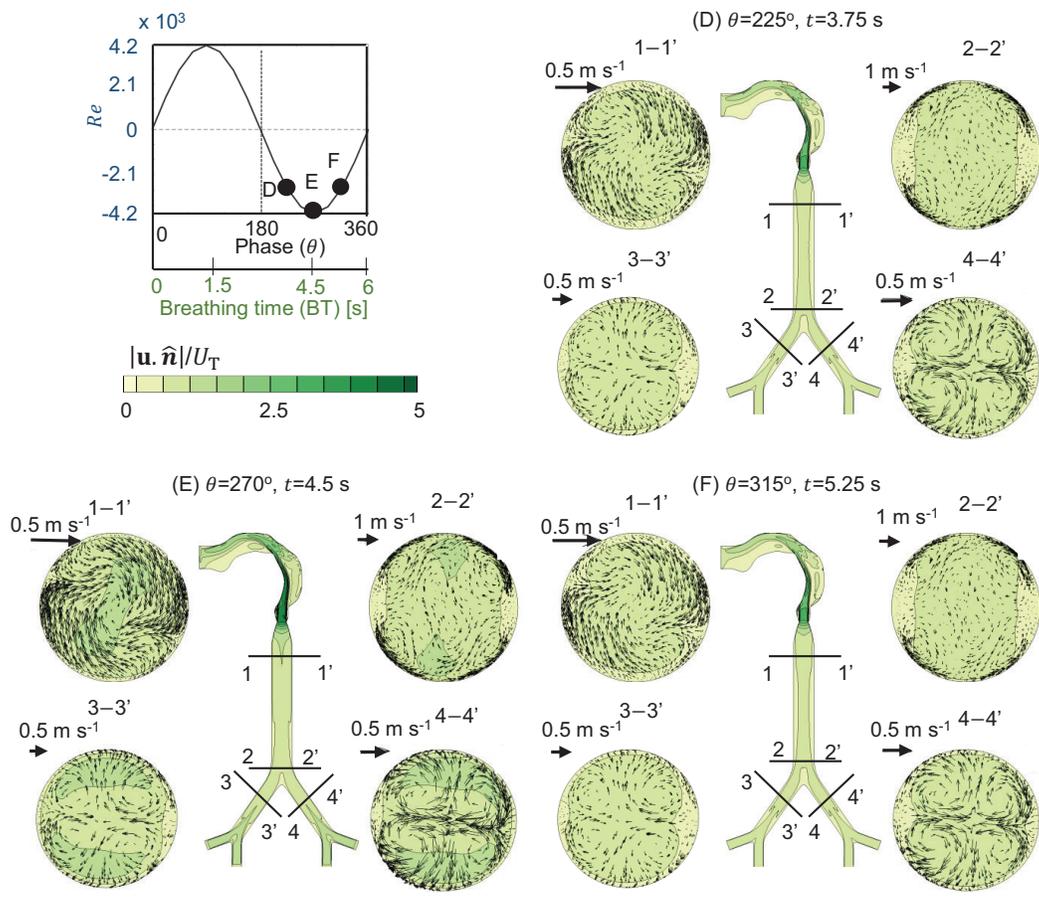
**Figure S1.** Time-step size independence test for  $Wo = 24.1$  and  $IT/BT = 50\%$ . Three-dimensional velocity ( $\mathbf{u}$ ) was extracted along the coronal plane in the upper trachea (plane 1 in **Table 2**) and plotted as a function of non-dimensional diameter  $y/D$ .  $D$  = trachea diameter = 18 mm.



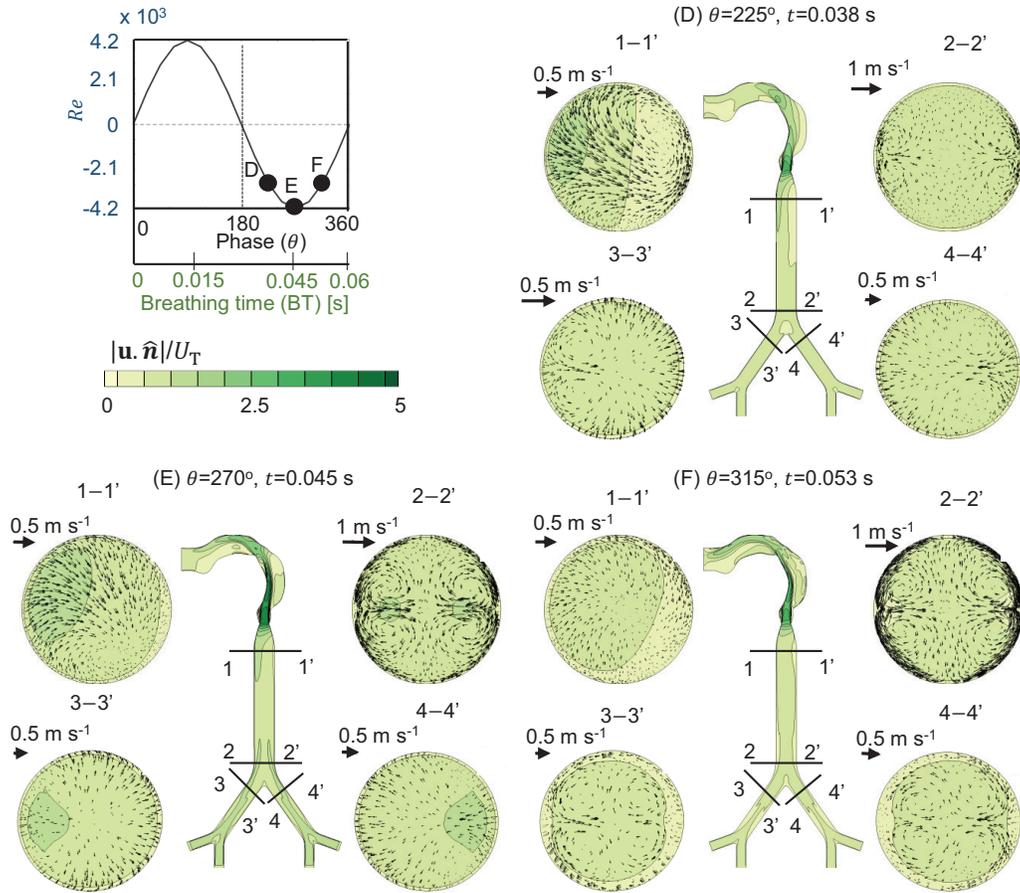
**Figure S2.** Contours of magnitude of plane-normal velocity component (non-dimensionalized with mean flow speed in trachea,  $U_T$ ) with superimposed in-plane velocity vectors for planes 1–4 at various time points during inhalation for  $Wo = 2.41$  at IT/BT = 33%. A is at phase  $\theta = 45^\circ$  (= 25% IT), B is at phase  $\theta = 90^\circ$  (= 50% IT) and C is at phase  $\theta = 135^\circ$  (= 75% IT). Coronal plane shows the locations of each plane.



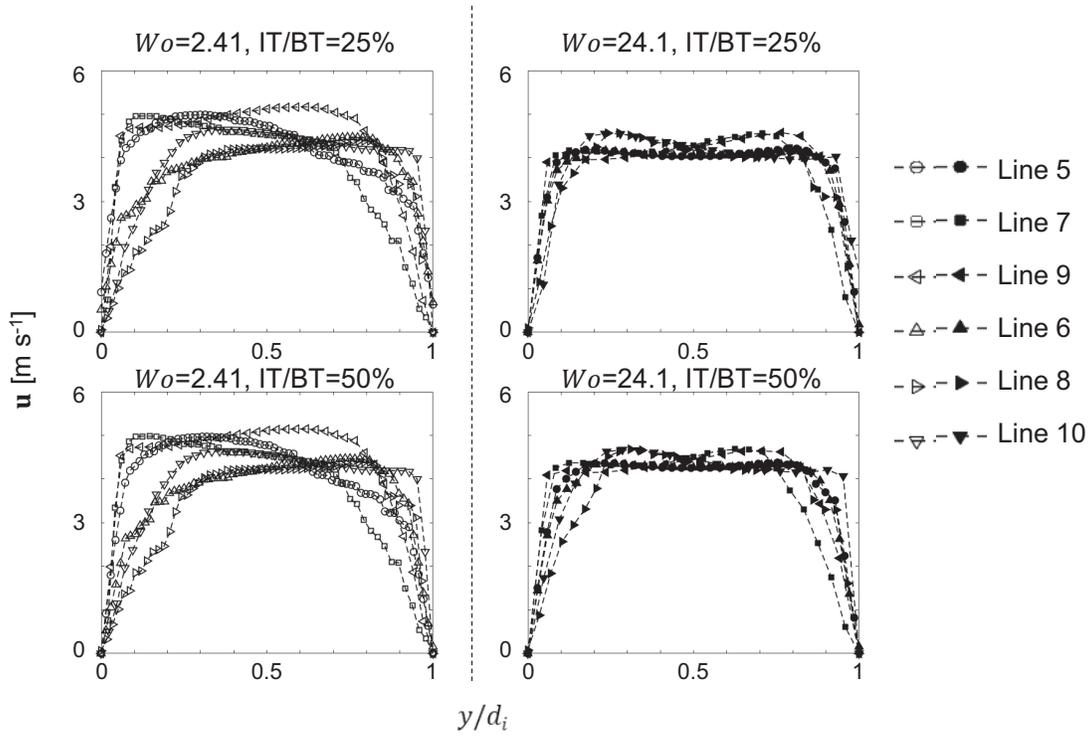
**Figure S3.** Contours of magnitude of plane-normal velocity component (non-dimensionalized with mean flow speed in trachea,  $U_T$ ) with superimposed in-plane velocity vectors for planes 1–4 at various time points during inhalation for  $Wo = 24.1$  at  $IT/BT = 33\%$ . A is at phase  $\theta = 45^\circ$  ( $=25\%$  IT), B is at phase  $\theta = 90^\circ$  ( $=50\%$  IT) and C is at phase  $\theta = 135^\circ$  ( $=75\%$  IT).



**Figure S4.** Contours of magnitude of plane-normal velocity component (non-dimensionalized with mean flow speed in trachea,  $U_T$ ) with superimposed in-plane velocity vectors for planes 1–2 at various time points during exhalation for for  $W_o = 2.41$  at IT/BT = 50%. D is at phase  $\theta = 225^\circ$  (= 25% ET), E is at phase  $\theta = 270^\circ$  (= 50% ET) and F is at phase  $\theta = 315^\circ$  (= 75% ET).



**Figure S5.** Contours of magnitude of plane-normal velocity component (non-dimensionalized with mean flow speed in trachea,  $U_T$ ) with superimposed in-plane velocity vectors for planes 1–2 at various time points during exhalation for for  $Wo = 24.1$  at IT/BT = 50%. D is at phase  $\theta = 225^\circ$  (= 25% ET), E is at phase  $\theta = 270^\circ$  (= 50% ET) and F is at phase  $\theta = 315^\circ$  (= 75% ET).



**Figure S6.** Velocity profiles along coronal plane at in planes 5-10 for varying  $Wo$  and IT/BT conditions. Three-dimensional velocity ( $\mathbf{u}$ ) was extracted along the line across the coronal plane diameter and plotted as a function of non-dimensional diameter  $y/d_i$ , where  $d_i$  is the airway cross-sectional diameter in  $i^{th}$  plane (refer **Table 2**).

**TABLE S1.** Local Reynolds number ( $Re_L$ ) and local Womersley number ( $Wo_L$ ) at each plane listed in Table 2.  $Re_L$  and  $Wo_L$  were calculated as:  $Re_L = \frac{V_L D_L}{\nu}$  and  $Wo_L = \frac{D_L}{2} \sqrt{\frac{1}{\nu} \left( \frac{2\pi}{BT} \right)}$ , where  $D_L$  is the local airway diameter at a given plane,  $V_L$  is the average local axial velocity,  $BT$  is the breathing time and  $\nu$  is the kinematic viscosity of air ( $\nu = 1.4 \times 10^{-5} \text{ m}^2 \text{ s}^{-1}$ ).

Location	Description	$Re_L / Wo_L$									
		$Wo = 2.41,$ IT/BT = 25%	$Wo = 2.41,$ IT/BT = 33%	$Wo = 2.41,$ IT/BT = 50%	$Wo = 7.51,$ IT/BT = 25%	$Wo = 7.51,$ IT/BT = 25%	$Wo = 7.51,$ IT/BT = 50%	$Wo = 24.1,$ IT/BT = 25%	$Wo = 24.1,$ IT/BT = 33%	$Wo = 24.1,$ IT/BT = 50%	$Wo = 24.1,$ IT/BT = 33%
Plane 1	Upper trachea (G0)	6794/2.4	6947/2.4	6894/2.4	6653/7.62	7165/7.61	7418/7.61	6750/24.8	6620/24.8	6602/24.8	
Plane 2	Lower trachea (G0)	4224/2.4	4228/2.4	4227/2.4	4210/7.61	4227/7.61	4247/7.61	4141/24.8	4224/24.8	4224/24.8	
Plane 3	Generation (G1)	3274/1.63	3276/1.63	3275/1.63	2956/5.15	2947/5.15	3237/5.15	3015/16.3	3076/16.3	3079/16.3	
Plane 4	Generation (G1)	3932/1.63	2933/1.63	2934/1.63	3235/5.15	3267/5.15	2984/5.15	3056/16.3	3118/16.3	3121/16.3	
Plane 5	Generation (G1)	3311/1.63	3315/1.63	3313/1.63	2992/5.15	2932/5.15	3264/5.15	3058/16.3	3119/16.3	3119/16.3	
Plane 6	Generation (G1)	2930/1.63	2931/1.63	2932/1.63	3229/5.15	3261/5.15	2980/5.15	3057/16.3	3119/16.3	3120/16.3	
Plane 7	Generation (G2)	2348/1.11	2359/1.11	2354/1.11	2135/3.53	2130/3.53	2324/3.53	2260/11.18	2307/11.18	2311/11.18	
Plane 8	Generation (G2)	2090/1.11	2104/1.11	2096/1.11	2284/3.53	2310/3.53	2118/3.53	2251/11.18	2298/11.18	2302/11.18	
Plane 9	Generation (G2)	2535/1.11	2531/1.11	2533/1.11	2278/3.53	2271/3.53	2489/3.53	2239/11.18	2286/11.18	2290/11.18	
Plane 10	Generation (G2)	2233/1.11	2221/1.11	2230/1.11	2468/3.53	2487/3.53	2270/3.53	2238/11.18	2285/11.18	2290/11.18	

## SUPPLEMENTARY MOVIES

**Movie 1.** Three-dimensional velocity (non-dimensionalized with peak mean flow speed in trachea,  $U_T$ ) and  $Q$ -criterion isosurface at various time points during normal breathing for  $Wo = 2.41$  at IT/BT = 25%, 33% and 50%.

**Movie 2.** Three-dimensional velocity (non-dimensionalized with peak mean flow speed in trachea,  $U_T$ ) and  $Q$ -criterion isosurface at various time points during normal breathing for  $Wo = 7.61$  at IT/BT = 25%, 33% and 50%.

**Movie 3.** Three-dimensional velocity (non-dimensionalized with peak mean flow speed in trachea,  $U_T$ ) and  $Q$ -criterion isosurface at various time points during normal breathing for  $Wo = 24.1$  at IT/BT = 25%, 33% and 50%.